DISCUSSION EXERCISE

1. The following activities were listed during a brainstorming session on product development. Find the appropriate predecessor-successor relationships and then construct an AON network to reflect the project using the activity duration times given in the information table. Assume a 5-day workweek. Find the critical path and time for the project. Find the slack for all activities.

   1. Organize the sales office: Hire sales manager. (6 weeks)

   2. Hire sales personnel: The sales manager will recruit and hire the salespeople needed. (4 weeks)

   3. Train sales personnel: Train the salespeople hired to sell the product to the distributors. (7 weeks)

   4. Select advertising agency: The sales manager will select the agency best suited to promote the new product. (2 weeks)

   5. Plan advertising campaign: The sales office and advertising agency will jointly plan the advertising campaign to introduce the product to the public. (4 weeks)

   6. Conduct advertising campaign: The advertising agency will conduct a "watch for" campaign for potential customers. (10 weeks)

   7. Design package: Have packaging engineer design the package most likely to "sell." (2 weeks)

   8. Set up packaging facility: Prepare to package the products when they are received from the manufacturer. (10 weeks)

   9. Package initial stocks: Package stocks received from the manufacturer. (6 weeks)

   10. Order and receive stock from the manufacturer: Order the stock from the manufacturer. The time given includes the time for delivery. (13 weeks)

   11. Select distributors: The sales manager will select the distributors whom the salespeople will contact to make sales. (9 weeks)

   12. Sell to distributors: Take orders from the distributors for the new product, with delivery promised for the product-introduction date. If orders exceed stock, assign stock on a quota basis. (6 weeks)

   13. Ship stock to distributors: Ship the packaged stock to distributors in accord with their orders or quota. (6 weeks)

   Question: What managerial problems and opportunities do you see as a result of your work?

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.

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.

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

Attack of the Killer Worm

Lee Antoinio was the CIO of a large publishing house. Her network administrator, Andy McPester, came to her one sunny September afternoon and informed her that a worm had attacked their network. It had shut down two of their 45 servers and had potential to harm the other servers as well as the 323 personal workstations throughout the enterprise. Andy knew that he could not report this problem to Lee without a recommended project plan for a solution. Andy and Lee had a good, trusting relationship, but Lee insisted that Andy investigate all options and come to her with the most viable solution to any problem.

Andy's project plan outlined that it would take 30 to 45 minutes to touch each PC to protect them from the worm, and longer if they were already infected. It would take almost an hour to check the other servers and repair them. Andy discussed the time estimates with his desktop staff. Andy proposed paying six staff members overtime to work 4 hours after their normal business day for the next week or two to check each personal workstation. He did not

want to affect productivity of the company's staff during the day. Andy proposed repairing the servers the same way with two additional staff members in the evenings. Lee felt that the time estimates and costs were too high. She did not think it would take that amount of time for each machine to get repaired. She was concerned that some of Andy's staff may have overestimated the time needed. She also was not sold on the notion that all the work would be done at night, paying staff overtime.

Question: How would you recommend they reach a consensus on the project plan?

9. When using AON networks, how does one indicate an event such as a project milestone?

10. A probabilistic network has a critical path of 21 days and a .95 probability of completing this path in 24 days. Therefore, the project has a .95 chance of being finished by the end of the 24th day. True or False? Briefly explain your answer.

11. "Not uncommonly, the Gantt chart is deceptive in its apparent simplicity." Briefly explain.

12. When activity times are known with certainty, the critical path is defined as 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. Why must this definition be modified in situations where the activity times are not known with certainty? Are there any dangers associated with not modifying the definition?

DISCUSSION QUESTIONS

1. Should a PM manage critical path tasks differently than noncritical path tasks?

2. How might you use the network approach to help prepare cost estimates?

3. When would it be accurate to determine the probability of project completion by multiplying the probabilities of all the paths through the network together? When would it not be accurate?

4. Reconsider Question 3. If this approach is not accurate, would the probability of completion considering the critical path alone be more accurate? How might you estimate the correct probability without resorting to simulation?

5. Why do you think most PMs use MSP's Gantt chart format (see Figure 5-20) more commonly than the network format?

6. Which of the linkages in precedence diagramming do you think is most commonly used? Why?

7. In the calculation of variance for optimistic and pessimistic activity duration estimates made at the 95 or 90 percent level, the denominator of the fraction that approximates the standard deviation of the time distribution changes from the traditional $(b - a)/6$ to $(b - a)/3.3$ for 95 percent and to $(b - a)/2.6$ for 90 percent. Where did the 3.3 and the 2.6 come from?

8. Given all the estimating done to determine the duration of project activities, what does it mean to say that "only after the fact do we know which path was actually the critical path?"

9. It was noted that "the PM must manage the project team as well as the project." Explain why.

10. Why do you think scheduling has been the major focus of effort throughout the history of project management rather than performance or budgeting?

EXERCISES

1. Refer to the network in Figure 5-14. What is the probability that path a-b-c-f will interfere with the promised project completion of 50 days? Recall that the critical path, a-b-d-g-h, had a probability of .86 for a 50-day completion. What is the probability that both paths will be complete in 50 days?

2. Refer to Table 5-4 and Figure 5-14. Recalculate the variance for each activity on the assumption that the optimistic and pessimistic estimates were made with a 95 percent probability. Recalculate the probability that the critical path will be completed in 50 days.

3. Refer to Table 5-4 and Figure 5-14. Recalculate the variance for each activity on the assumption that the optimistic and pessimistic estimates were made with a 90 percent probability. Again, recalculate the likelihood that the critical path will be finished in 50 days.

4. Given the information in the following table:

Activity	Duration	Predecessor
a	4	None
b	6	a
c	4	a
d	2	c
e	4	b
f	5	b, d
g	3	c
h	4	f, g
i	2	e, h

(a) Construct the network diagram.

(b) Find each activity's ES, EF, LS, and LF.

(c) Identify all paths. Which path is the critical path?

(d) Calculate the slack for each activity.

(e) How long will it take to complete the project?

5. In the following table, task durations are given in weeks. The estimates were made at the 95 percent level (see Section 5.2, Calculating Probabilistic Activity Times subsection).

Activity	Predec.	Opt.	Normal	Pess.
a	—	2	4	6
b	—	3	5	9
c	a	4	5	7
d	a	4	6	10
e	b, c	4	5	7
f	d	3	4	8
g	e	3	5	8

(a) Find the expected time and variance for each task.

(b) Draw the network (either AOA or AON) and find the path with the longest expected time. What is the expected time to complete this path?

(c) Find the probability using the analytical approach that the path with the longest expected time will be completed in 23 weeks.

(d) Find the probability that the other paths will be completed in 23 weeks.

(e) Using simulation, what is the probability that the entire network will be completed in 23 weeks?

6. Given an auditing project with the following activities:

Activity	Std. Dev.	Critical	Duration (wks)
a. Add	2	Yes	2
b. Balance	1		3
c. Count	0	Yes	4
d. Deduct	3		2
e. Edit	1	Yes	1
f. Finance	2		6
g. Group	2	Yes	4
h. Hold	0	Yes	2

Using the analytical approach find:

(a) The probability of completing this project in 12 weeks or less, as the client desires.

(b) The probability of completing this project in 13 weeks or less.

(c) The probability of completing this project in 16 weeks or less, the client's drop-dead date.

(d) The number of weeks required to assure a 92.5 percent chance of completion, as guaranteed by the auditing firm.

7. Resolve the previous exercise using computer simulation and compare your answers. Explain any differences you observe. Which methodology do you have more confidence in and why?

8. Referring to the previous two questions, modify your simulation model to develop distributions for the slack time of each path. What do these distributions tell you?

9. Given the following information regarding a project involving an initial public offering (IPO):

Activity	Duration (weeks)	Preceding Activities
a. Check feasibility	3	—
b. Determine funding	1	—
c. Find possible banks	3	a
d. Select two possibles	4	a
e. Interview two banks	4	b
f. Analyze funding costs	5	b
g. Determine chance of success	2	c, e
h. Sign contract	3	f

(a) Draw the network.

(b) What is the critical path?

(c) When will the offering be available (end of the project)?

(d) What is the effect on the project if activity e (approvals) takes an extra week? Two extra weeks? Three extra weeks?

10. Enter the following information into an Excel® spreadsheet. The time estimates were made at the 90 percent level (see Section 5.2, Calculating Probabilistic Activity Times subsection). All activity times are in days.

Activity	Predec.	Opt.	Normal	Pess.
a	—	5	6	9
b	—	4	4	6
c	—	7	9	15
d	a	6	6	6
e	b	4	5	7
f	b	12	16	17
g	c	8	12	20
h	c	7	9	16
i	d, e	10	14	18
j	f, g	6	12	20
k	h	7	9	14

(a) Draw the network. (You may use MSP, or draw an AOA or AON network by hand.)

(b) Using Excel®, calculate the expected time (T_e) and variance for each activity.

(c) Using the expected times, find the path with the longest expected time. What is the expected time to complete this path? (Use the analytic method.)

want to affect productivity of the company's staff during the day. Andy proposed repairing the servers the same way with two additional staff members in the evenings. Lee felt that the time estimates and costs were too high. She did not think it would take that amount of time for each machine to get repaired. She was concerned that some of

Andy's staff may have overestimated the time needed. She also was not sold on the notion that all the work would be done at night, paying staff overtime.

Question: How would you recommend they reach a consensus on the project plan?

C A S E

Friendly Assisted Living Facility
Program Plan—5

The steering team meeting held August 31 went quite well. Fred felt that his team members had worked well together at determining the steps and the associated costs of the program. The CFO presented the program budget first, and then project team members presented their draft project plans.

The COO presented the following project plan:

ID	Task Name	Duration	Predecessors	Resource Names
1	Operational Implementation Plan			
2	Management/Organization structure	87 days		CFO, Legal, VP Mktg
3	Recruit & hire Executive Director	17.4 wks		Splient
4	Interior design issues decided (furnishings, etc.)	20 days		COO
5	Determine what was provided with lease and what was furnished in some units	2 wks		
6	Determine budget for interior	10 days		
7	Carpet and wall finish determined	2 wks	59	
8	Furniture and room layout	2 wks	59	
9	Facility and equipment needs defined	4 wks		COO
10	Staffing determined	2 wks		COO, Dr. Link
11	Office space for physicians	4 wks		Dr. Link
12	Medical staffing needs determined & Director appointed	4 wks		Dr. Link
13	Food service	45 days		
14	Menus selected	8 wks		
15	Waiting and service staffing needs determined	4 wks		
16	Additional equipment needs	4 wks	68FS—3wks	
17	Telecommunications services	45 days		
18	Investigate phone service options	45 days		Chief Engineer
19	Certification/Accreditation requirements	42 days		
20	Investigate requirements & timing of applicants with Dept. of Health to open facility	0 days		Legal
21	Develop clinical and operational quality monitoring systems	0 days		
22	Develop financial systems (billing, etc.)	6 wks		CFO
23	Human resources	79 days		HR Director
24	Work force management recommendations	6 wks		HR Director
25	Project plan for recruitment developed	2 wks	78	
26	Policies and procedures developed	60 days		
27	Obtain 'samples' of assisted living policies & procedures from other institutions	4 wks		Legal
28	Investigate assisted living laws proposed in other states/ federal	12 wks		Legal
29	Technology & information systems	344 days		CIO
30	Develop plan for technology access for residents (TV, Cable, PC's)	3 wks		
31	Investigate software/technology options for residents	12 wks		CIO

The Chief Legal Counsel for the medical center presented his project plan. Fred had asked him to join the team when it became apparent that there were significant compliance and legal issues associated with this project.

ID	Task Name	Duration	Predecessors	Resource Names
1	Legal and Licensing Requirements	154 days		
2	Research licensing requirements for residential care facility	38 days		Legal
3	Uniform accessibility standard compliance (# hndcp accessible beds)	2 wks		
4	Investigate law firm and outline services	4 wks		
5	Prepare project plan for license	2 wks	39	
6	File license—by opening date	0 days	40	
7	Curb-cut approval from county (access to County Rd.)	53 days		Legal
8	Investigate corporate structure for assisted living	115 days		Legal, CFO
9	Determine Board of Trustee membership	3 wks		
10	Appoint Board of Trustees	4 wks	44	
11	Prepare draft Code of Regulation	4 wks	45	
12	Prepare document and filing of governance structure	12 wks	46	
13	Draft service agreement with Friendly Medical Center for services provided	4 wks	47	Legal
14	Lease issues	110 days	48	Legal
15	Research Long Term Care insurance requirements	12 wks		
16	Facility "rules" defined (i.e., smoking, firearms, pets, financial planning)	4 wks	50	
17	Spell out changes for residents in moving from "light" to "heavy" assisted	6 wks		
18	Lease template prepared	6 wks	52, 50, 51	
19	Review all marketing materials for compliance	154 days		Legal

The Vice President of Marketing presented her project plan and stated that she and her staff were responsible for every step in the plan. She was still working with her staff to determine who does what. The Marketing VP made it clear to the team that she needed 5 months for the marketing plan implementation to be able to meet the occupancy requirements at start-up. She restated that her team must have this lead time to the completion of the construction and furnishing phase of the Program.

ID	Task Name	Duration	Predecessors
1	Marketing	270 days	
2	Community mailing about construction project	0 days	
3	Initial informational meetings	16 days	
4	Friendly Medical Center volunteers	1 day	
5	Community groups	4 days	
6	Friendly Medical Center staff (all shifts)	3 days	
7	Presentation prepared for Speaker's Bureau	0 days	88
8	Provide updates to community	0 days	92
9	Inquiry log established	0 days	88
10	Groundbreaking ceremony—during National Hospital Week	0 days	
11	Marketing plan developed and implemented	180 days	
12	PR firm contracted	4 wks	
13	Marketing plan developed	8 wks	97
14	Determine name and signage for facility	0 days	98
15	Hire Marketing Director	4 wks	98
16	Marketing plan ready to implement	0 days	98, 100
17	Implementation of marketing plan—5 months before facility ready, then ongoing	20 wks	101

As Fred was explaining that the next job of the group was to complete a final version of all project plans and firm up the schedule of the Program, the Construction Project Manager stated that it was his turn to present his broad project plan for construction of the facility. He also added that he had a major scheduling issue to bring to the team. The Construction Project Manager presented the following broad project plan for facility construction.

ID	Task Name	Duration	Predecessors
1	Construction & Furnishing	369 days	
2	Facility construction	329 days	
3	Phase 1 - Foundation & excavation (basement/1st floor slab)	95 days	
4	Phase 2 - Structure (steel/framing)	113 days	3FS—60 days
5	Phase 3 - Enclosure (masonry/windows/roof)	134 days	3
6	Phase 4 - Interiors (drywall/ceiling/flooring/case goods)	234 days	3
7	First 45 (light assisted) units ready to prepare for occupancy	0 days	6FS—5 wks
8	First 45 units ready for residents	8 wks	7
9	Remaining 57 units (light & heavy) ready to prepare for occupancy	0 days	6
10	Construction complete	0 days	9
11	Building ready for residents	8 wks	10

The construction PM proceeded to explain that the scheduling constraints that the Board of Trustees gave the team were not feasible. The Board wanted construction to begin immediately after the elections in November and to be ready for occupants by June. The contractor did not want to begin the project at the beginning of winter. The first phases of the project plan detailed work that needed to be completed outside. If the weather was bad, the construction PM knew the schedule would be affected. The construction project manager also pointed out that the schedule created by the contractor was designed around a 40-hour, 5-day workweek. If the building project began in November, the estimated project duration would be increased by 1 to 2 months, during which time some construction crewmen would have to be paid, thereby increasing the building cost.

The PM recommended that construction begin in February or March of the following year, which would give the facility a shorter build time and a lower cost. The budget and project duration submitted were based on a March 1 start date. He stated that the construction phase of the project did not need to hold up the other members of the Program team—they could begin their work on their projects anytime.

QUESTIONS

1. Draw a Gantt chart for the construction phase of the program. What is the completion date if construction starts in March? What is the completion date of the project if construction is started in November?

2. Why is it not possible to meet the scheduling constraints set by the Board? What is your recommendation to handle the scheduling problem?

3. When will the program be completed based on your recommendation?

4. Develop a Gantt Chart of the Marketing Plan and Implementation Phase of the Program. Determine the start date of the Marketing Plan project in order to meet your recommended facility ready for occupancy date.

5. What is the next step the team members must take in order to complete their project plans?

C A S E

NutriStar

NutriStar produces a line of vitamins and nutritional supplements. It recently introduced its Nutri-Sports Energy Bar, which is based on new scientific findings about the proper balance of macronutrients. The energy bar has become extremely popular among elite athletes and other people who follow the diet. One distinguishing feature of the Nutri-Sports Energy Bar is that each bar contains 50 milligrams of

important to have excess capacity in the airport control tower?

7. Explain the difference in the problems faced by a PM who is short of secretarial resources and one who is short of a "Walt."

8. When allocating scarce resources to several different projects at the same time, why is it important to make sure that all resource calendars are on the same time base (i.e., hourly, daily, weekly, etc.)?

9. List and describe the three most common criteria by which to evaluate different resource allocation priority rules.

10. Why is the problem of allocating scarce resources to a set of projects similar to the problem of scheduling a job shop?

11. What is meant by the term "student syndrome?"

12. Describe in your own words what is meant by Goldratt's critical chain. How does it work?

DISCUSSION QUESTIONS

1. Describe the fundamental trade-offs made when deciding whether or not to crash a project. If the decision is made to crash, what additional trade-offs must be made?

2. Discuss the advantages of "labor pools" in a project-oriented company. Are there any potential disadvantages with the use of pools?

3. What purpose(s) might be served by using each of the following priority rules for allocating scarce resources?

   a. As late as possible

   b. Shortest task duration time first

   c. Minimum slack first

4. Linking a group of projects together with pseudoactivities creates a sort of superproject. What does this mean, and why would anyone want to do it?

5. Projects A and B are both nearing completion. You are managing a super important project C that requires an immediate input of a resource being used by both projects A and B, but is otherwise unavailable. Project A has a Type 1 life cycle. Project B's life cycle is Type 2. From which (or both or neither) do you borrow the resource? Why?

6. Goldratt suggested that to avoid the "student syndrome," it is a good idea to set activity durations so short that there is a high probability that the task will not be finished on time. On the other hand, it has long been known that setting people up for failure is strongly demotivating. What should the PM do?

7. Describe as many types of resource allocation problems as you can, based on the situations described in the chapter.

EXERCISES

1. Given the following project to landscape a new building site:

Activity	Immediate Predecessor	Activity Duration (days)	Resource Used
A	—	2	X, Y
B	A	2	X
C	A	3	X
D	B, C	4	X, Y
E	D	3	W, X
F	D	1	W, X, Y
G	E, F	2	X, Y

   a. Draw a Gantt chart using MSP.

   b. Assuming a 5-day week, find the critical path and project duration in days.

   c. Given that each resource is assigned 100 percent to each task, identify the resource constraints.

   d. Using the MSP default, level the resources and determine the new project duration and critical path.

   e. Identify what alternative solutions can be used to shorten the project duration without overallocating the resources.

2. Given the following project (all times are in days):

Activity	Predecessor	Normal Time	Normal Cost	Crash Time	Crash Cost
a	—	5	$50	3	$150
b	—	4	40	2	200
c	b	7	70	6	160
d	a, c	2	20	1	50
e	a, c	3	30	—	—
f	b	8	80	5	290
g	d	5	50	4	100
h	e, f	6	60	3	180

a. Draw the network (AOA or AON) and find the critical path, time, and cost for an all-normal level of project activity.

b. Calculate the crash cost-per-day (all activities may be partially crashed).

c. Find the optimal way of getting an 18-day delivery time. What is the project cost?

d. Find the optimal way of getting a 16-day delivery time. What is the project cost?

e. Calculate the shortest delivery time for the project. What is the cost?

3. Given the following AOA network, determine the first activity to be given extra resources by the following priority rules:
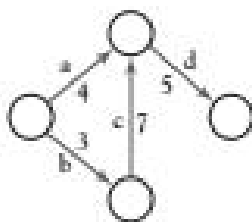

a. Shortest task first

b. Minimum slack first

c. Most critical followers

d. Most successors

4. Given the project shown in Figure 5-10 of Chapter 5, assume that a facility used by activities c and d is scarce. To which activity would you assign the facility first, given the following rules:

a. Minimum slack rule

b. Most followers

c. Most critical followers

d. Shortest task first

e. As late as possible

5. Consider the following activity information and the constraint that the project must be completed in 16 weeks.

Activity	Duration (weeks)	Preceding Activity
A	3	—
B	6	—
C	8	—
D	7	A
E	5	B
F	10	C
G	4	C
H	5	D, E, F
I	6	G

In addition, activity C may be crashed to 7 weeks at a cost of $40, activity F may be crashed to 6 weeks at a cost of $20/week, activity H may be crashed to 2 weeks at a cost of $10/week, and activity I may be crashed to 3 weeks at a cost of $30/week. Find the best schedule and cost.

6. Consider the project network below. Suppose the duration of both activities A and D can be reduced to 1 day, at a cost of $15 per day of reduction. Also, activities E, G, and H can be reduced in duration by 1 day, at a cost of $25 per day of reduction. What is the least-cost approach to crash the project by 2 days? What is the shortest "crashed" duration, the new critical path, and the cost of crashing?
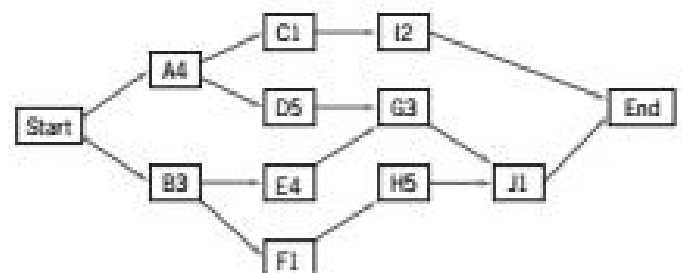
7. The network for shooting a TV commercial as shown in the table has a fixed cost of $90 per day, but money can be saved by shortening the project duration. Find the least-cost schedule.

Activity	Normal Time	Crash Time	Cost Increase (1st, 2nd, 3rd day)
1–2: Contract personnel	7	4	$30, 50, 70
2–3: Obtain stage props	9	6	40, 45, 65
1–3: Rent equipment	12	10	60, 60
2–4: Contract studio	11	9	35, 60
3–4: Set time and date	3	3	—

8. Given a network for an HR training project with normal times and crash times (in parentheses), find the cost-duration history. Assume indirect costs for facilities and equipment are $100 per day. The data are:

Activity	Time Reduction, Direct Cost per Day
1–2: Obtain room	$30 first, $50 second
2–3: Select trainer	$80
3–4: Invite personnel	$25 first, $60 second
2–4: Check budget	$30 first, $70 second, $90 third