明新科技大學九十三學年度研究所碩士班 □一般生 ■在職生 招生考試入學試題卷

系所別	組別	科目	准考證號碼	考試日期	節次	時間
工程管理研究所		案例分析與論文討論		93 年 5 月 2 日	第一節	100 分鐘

註：(1) 請在答案卷依題次順序作答。(2) 可使用計算器(需不具程式儲存功能)。(3) 不可使用翻譯機、字典。(4) 除專有名詞外，請以中文作答。

一、　案例分析 （50 分）：

近年來，真正的供應商協同（supplier collaboration），因著協同規劃、預測、補貨之程序而邁開一大步（collaborative planning, forecasting, and replenishment, CPFR）。嚴格說起來，對於能夠達到良好的供應鏈合作，CPFR 可說是一個主要的關鍵。根據 West Marine 的資深副總裁 — Larry Smith 在 2003 年的運籌管理年會上指出：「供應商對於即將到來的事件作及時的資料分享，將會影響其接單的數量與能力。」Smith 更清楚指出 CPFR 有三項主要的活動：

1. 規劃—共同在組織中或跨組織之程序規劃，並快速解決主要的困難，及供應鏈體系有效的運輸貨物，
2. 預測—必須能夠獲得可靠的訂單之預測，使得供應鏈體系的各個成員能夠真正準時的生產、製造、與配送，
3. 補貨—是一個需要及時完成的活動，其中供應鏈的成員包括配送端及銷售端，需要正確且完整之資訊。

許多公司花了許多時間在協同預測，但鮮少有像 West Marine 針對訂單作預測。Smith 更指出，我們的「供應鏈中心」（supply chain hub）必須負責預測的責任，並在資料達到供應商前，先進行顧客導向的預測及生產線之規劃，因此我們的位置是提出一個預測的參考值給供應商。Smith 針對上述，指出針對顧客導向的預測有幾個重要的理由：

1. The buyer usually drives the key events that “crack the bullwhip” in the supply chain (promotions and assortment changes).
2. The buyer driven forecast depends on only one technological platform and is therefore scalable across many items and suppliers with similarly accurate results.

根據上述所提出的方式，West Marine 已成功的建置他的企業模式，其中包含眾多的銷售項目與供應商等，並縮短其供應鏈長度。截至目前為止，West Marine 已經延伸他的 CRPF 計畫到 200 個供應商，並應用於 20,000 項目。

在某些可能的程度，我們想要包括所有的需求與訂購在我們的銷售預測，及供應商的未來訂單預測。我們也對供應商承諾所有的增加、或分類的改變，將會包含所有的供應商的物料需求規劃。因此 West Marine 已成功的建置企業流程與技術平台，提供供應商正確的訂單預測，因此他們也可以直接利用先進商店與倉儲之物料再

補充軟體（Advanced Store and Warehouse Replenishment software）作為整合式訂單程序的依據。

………………

West Marine 有超過兩年以上的經驗在於訂單的分享與正確的衡量物料需求預測給其供應商，他們的預測正確率可達到 85%，其中包括所購買的品項正確率、預測的數量水準等，而這樣的預測正確水準使得其供應商可以達到 90%的訂單滿足水準。

………………

(本篇內容翻譯自 Supplier Selection & Management Report, New York, April, 2004, v4, n4, p7.)

請回答下列問題（每題 10 分）：

1. 根據上述的個案，請給予以上之文章適當的標題。
2. 請簡要說明本篇之主旨為何（約 300 字左右）？
3. 請以中文說明，Smith 認為顧客導向的預測有幾個重要的理由？又何謂 bullwhip effect，請說明之。
4. 請您簡單描述過去的預測方式有哪些？其又與 CPFR 的預測方式之差異為何？
5. 看完上述的個案，您認為 CPFR 的主要精神為何？

二、 論文討論 (50 分)：

請閱讀下面這篇文章，並回答相關問題（每題 10 分）：

1. 請說明本文主旨（100 字以內）。
2. 請寫出至少三個關鍵詞並說明之。
3. 請問文中作者使用何種方法取得 project buffer 的大小？
4. 作者使用 Goldratt 的方法與傳統方法其結果的差異如何？
5. 請說明本文之結果與貢獻（200 字以內）。

QUANTIFYING BUFFERS FOR PROJECT SCHEDULES

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EXAMPLE PROJECT

The proposed procedure for determining project and feeding buffers is best explained with a simple example rather than a mathematical presentation. The required scheduling data for an example project are given in table 1. We assume for this example that the time to perform each activity is normally distributed. Other probability distributions could be used; however, the normal probability distribution is both familiar and reasonable. These data can be used to develop a project network and schedule as shown in figure 1.

TABLE 1: Data for Example Project

Activity	*Expected Activity Time (Weeks)*	*Standard Deviation Of Activity Time (Weeks)*	*Immediate Predecessors*
A	10	1	–
B	5	2	A
C	10	1	A
D	3	1	A
E	4	2	B
F	6	1	C, E
G	5	1	D, F

Close examination of the project network in figure 1 shows that activities B and E form a short string of activities that merge with the critical path formed by activities ACFG. Activities B and E each have a slack of one week and form part of a near-critical path, ABEFG. In contrast, activity D has a slack of 13 and is unlikely to affect the project completion date.

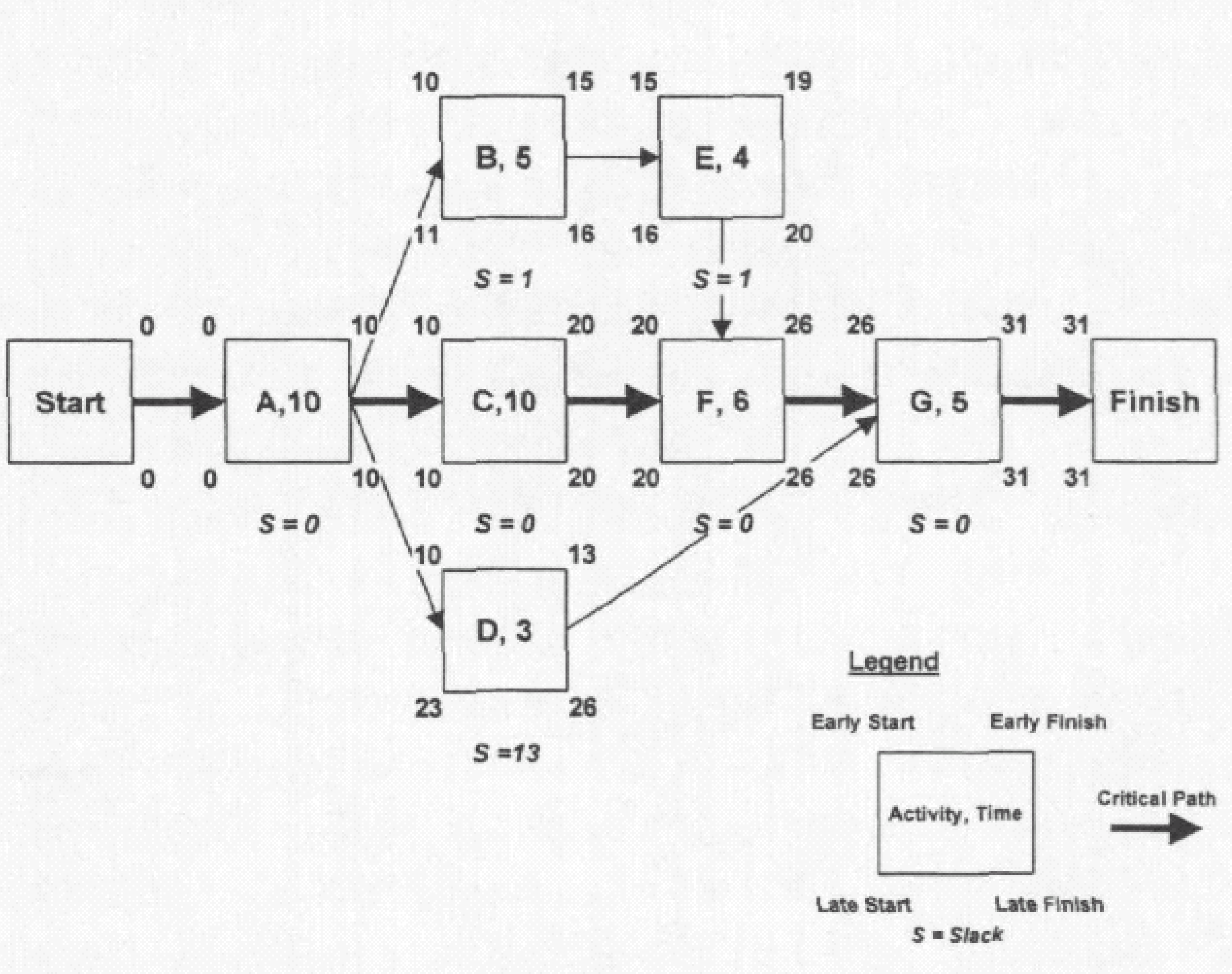

FIGURE 1: Network for example project

TABLE 2: Inflated Activity Times for Example Project

Activity	Inflated Activity Times (Weeks)
A	11.3
B	7.6
C	11.3
D	4.3
E	6.6
F	7.3
G	6.3

SCHEDULING WITH INFLATED TIME ESTIMATES

Goldratt [3, p.45] suggests that people inflate activity time estimates so that there is an 80–90% probability of finishing an activity on time. For our example problem, assume that the true standard deviation in activity times is given in table 1 and that people inflate time estimates to give a 90% probability of on-time completion for each activity. Using a cumulative normal probability distribution, we find that the inflated time estimates will be 1.28 standard deviations above their expected values. These inflated activity times are given in table 2, and the corresponding project network and schedule are given in figure 2.

A comparison of the two schedules shows that inflating activity times increases the project duration from 31.0 weeks to 39.1 weeks. Thus, inflating activity time estimates adds 8.1 more weeks to the project. That is slightly more than a 25% increase in the project du-

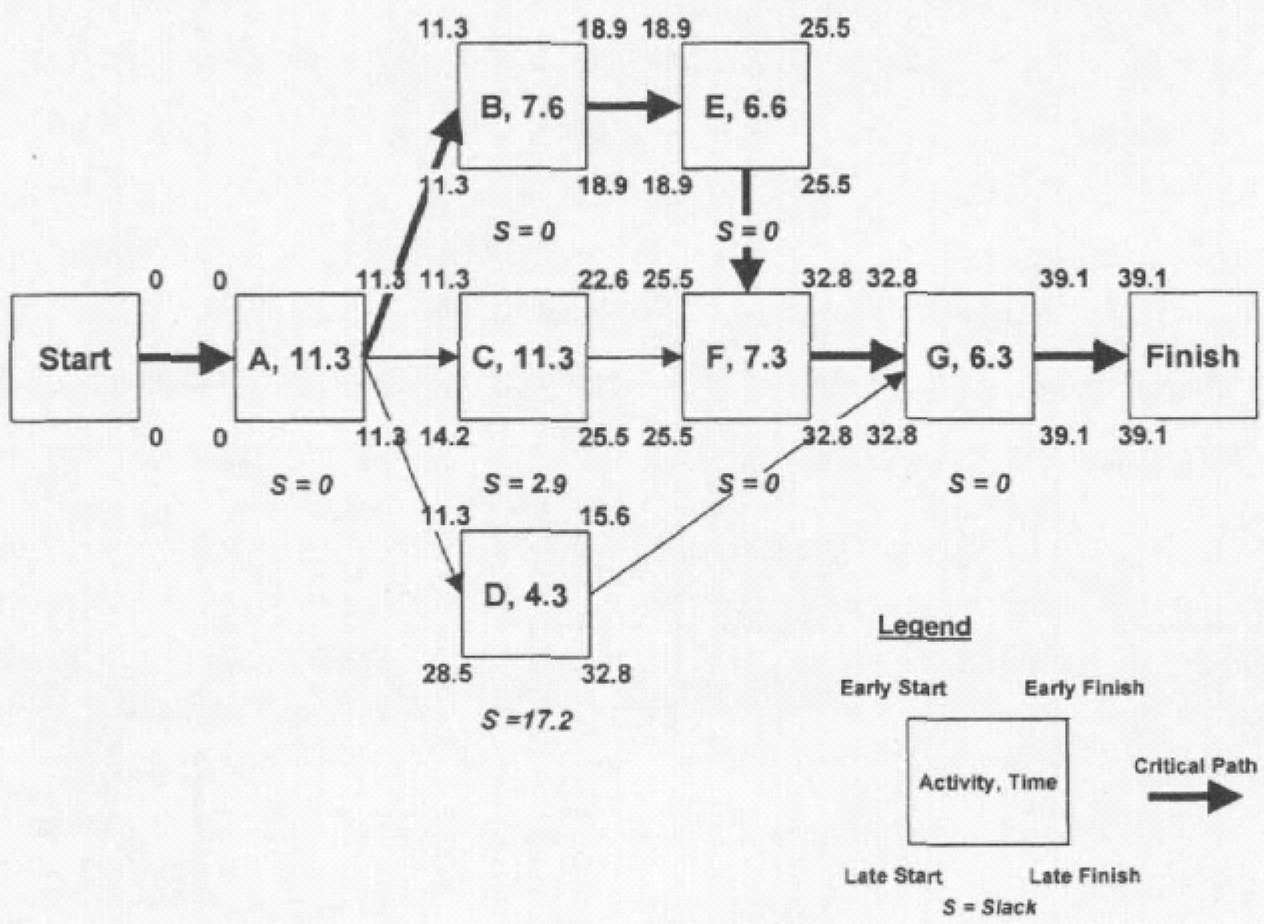

FIGURE 2: Network for project using inflated activity times

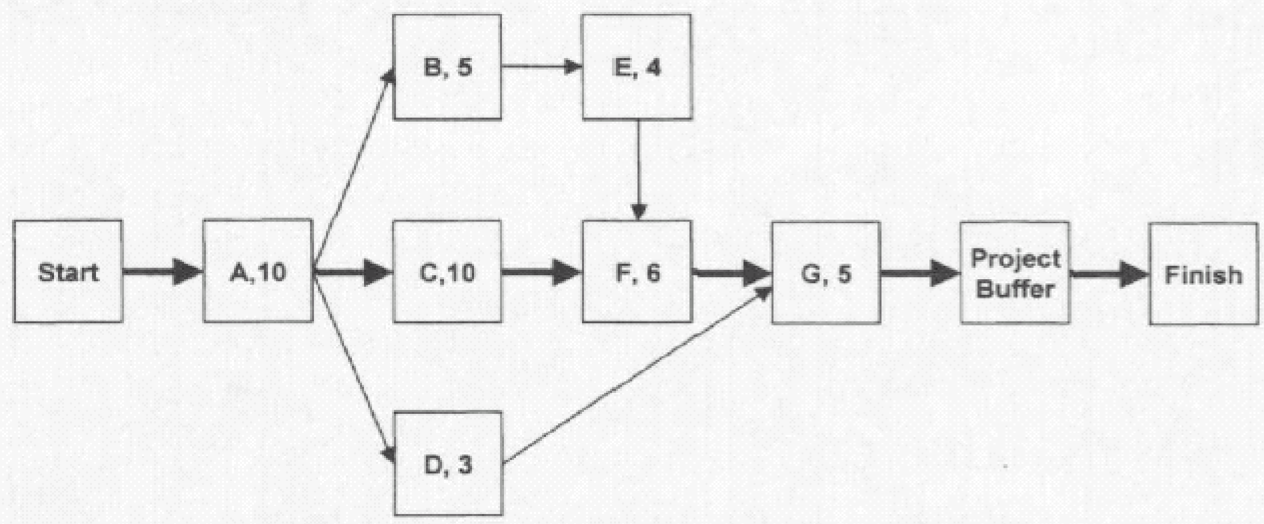

FIGURE 3: Network for project with a project buffer

ration. If we can implement Goldratt's ideas and use the expected time estimates for individual activities, then we have up to 8.1 weeks for a project buffer and reductions in the project duration. A *project buffer* is a time buffer placed at the end of the project network to protect the project from variation in activity times. The expanded project network with a project buffer is shown in figure 3.

Unfortunately Goldratt [3] gave little guidance on the sizing of project buffers. We will present a method for doing so in the next section. But first we will examine the impact of inflating time estimates on the critical path in our example problem.

A comparison of the schedule using the expected activity times (shown in fig. 1) with the schedule using inflated activity times (shown in fig. 2) reveals that the critical path shifted from ACFG to ABEFG. That shift was caused by the greater uncertainty in activities B and E, which is reflected in their higher standard deviations. The greater uncertainty resulted in more safety time being added to the expected activity times for activities B and E. That, in turn, caused a shift in the critical path.

This shift illustrates one possible effect of inflated activity time estimates. People will add more safety time for activities having greater uncertainty, which, in turn, may cause a shift in the critical path as illustrated in our example. The shift may then cause a project manager to concentrate on an incorrect critical path.

QUANTIFYING PROJECT BUFFERS

Goldratt [3] proposed that expected activity times be used for project scheduling and that uncertainty in project times be counterbalanced with a single project buffer. The project buffer, which provides a safety time for the entire project, replaces the safety time given by inflating individual activity time estimates (see fig. 3). Although Goldratt does not give us much guidance on how to determine the size of a project buffer, there are readily available project simulation tools that can be used to size project buffers.

Project Simulation

Monte Carlo simulation techniques have been used for many years to analyze project completion probabilities. Project simulation is discussed in project management texts such as Davis, Moder, and Phillips [2]; in simulation texts such as Pritsker, Sigal, and Hammerfar [5]; and in construction management literature such as AbouRizk and Halpin [1]. In addition, project simulation capability is available as an add-in or module for some commercial project scheduling software.

Let us now examine the use of simulation to size project buffers for our example problem. Using the data in table 1, the example project was simulated with ten thousand trials. Key simulation results are summarized in table 3, and a cumulative probability distribution for the project completion time is given in figure 4.

The Expected Value Trap

The project simulation results show a slight increase in the mean project time when simulation is used instead of expected activity times. The mean project time for the simulation was 31.7 weeks. In contrast, the project time using the expected values was 31.0 weeks, as shown by the schedule in figure 1.

The probability of an activity being on the critical path is given by its criticality index. Thus as shown by the criticality indices in table 3, activity A was on the critical path in all the simulation trials, activity B was on the critical path in 37% of the trials, activity C was on the critical path for the other 63% of the trials, and activity D was never on the critical path.

Examination of the criticality indices shows that the path ABEFG was critical in 37% of the trials. Use of expected activity times to calculate project completion

TABLE 3: Key Simulation Results

Mean Project Time	31.7 weeks
Minimum Project Time	22.6 weeks
Maximum Project Time	41.7 weeks
A Criticality Index	1.00
B Criticality Index	0.37
C Criticality Index	0.63
D Criticality Index	0.00
E Criticality Index	0.37
F Criticality Index	1.00
G Criticality Index	1.00

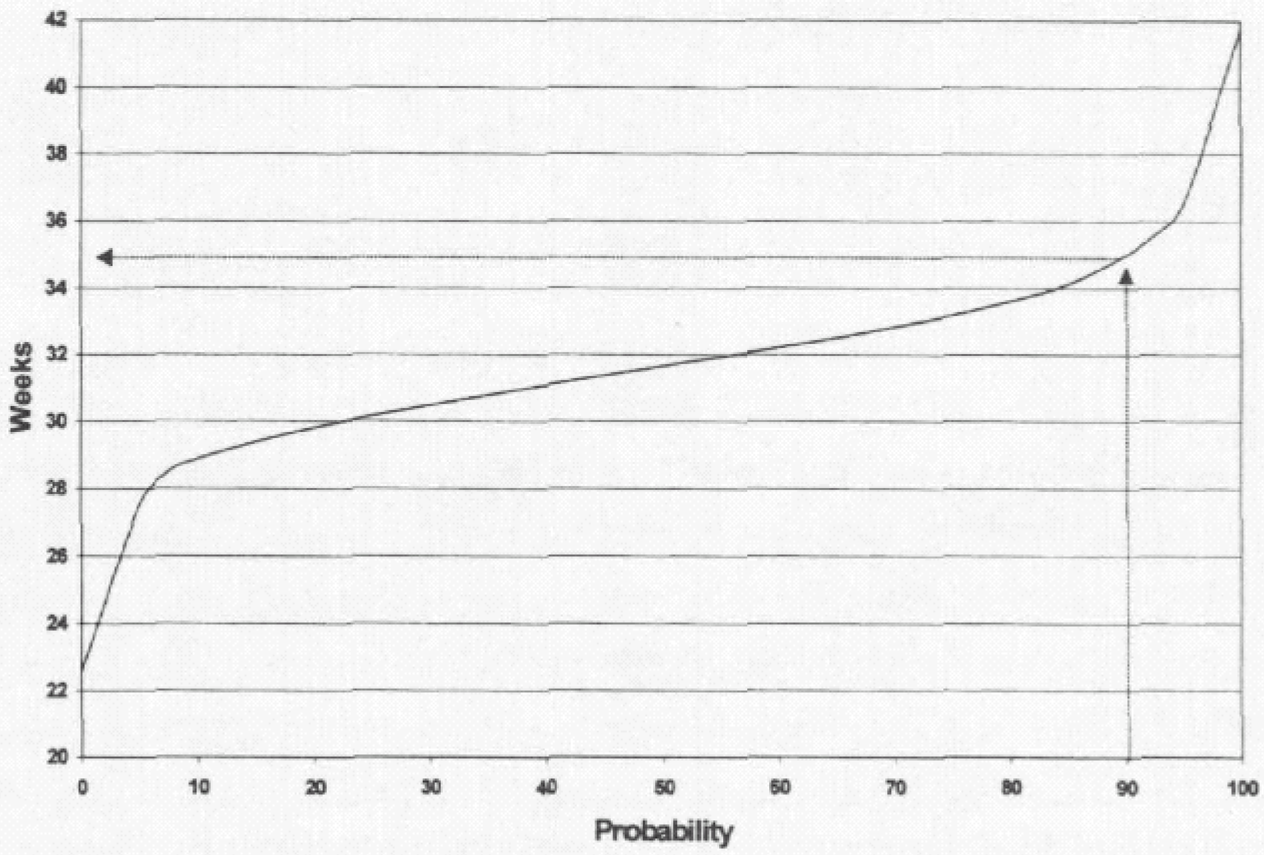

FIGURE 4: Simulated project completion probabilities

times overlooks the impact of this near-critical path and assumes that path ACFG will always be the critical path. In contrast, the simulation model captured the effect of the near-critical path, resulting in an increase in the expected project completion time.

This situation is not unique to our example; it occurs in most projects that have near-critical paths. This understating of project completion times is an example of the "expected value trap," which occurs when an incorrect answer is given by using a deterministic solution procedure for a probabilistic problem.

Sizing Project Buffers

The size of the project buffer depends on the desired probability for completing the project on schedule. The cumulative probability distribution in figure 4 shows the relationship between project completion probabilities and project time. Suppose, for example, a 90% probability of completing the project on schedule was desired. Reading from the graph we see that the probability of completing the project in 35 weeks or less is 90%. The project buffer is the difference between the 90% project completion time of 35 weeks and the simulated expected project completion time of 31.7 weeks. Thus, a project buffer of 35 – 31.7 = 3.3 weeks is required.

Comparing that result to the project schedule shown in figure 2 (where individual activity times were inflated to give a 90% probability of completing the activity on time) shows the benefits of Goldratt's approach. The project schedule with inflated activity times requires 39.1 weeks. In contrast, the schedule with a

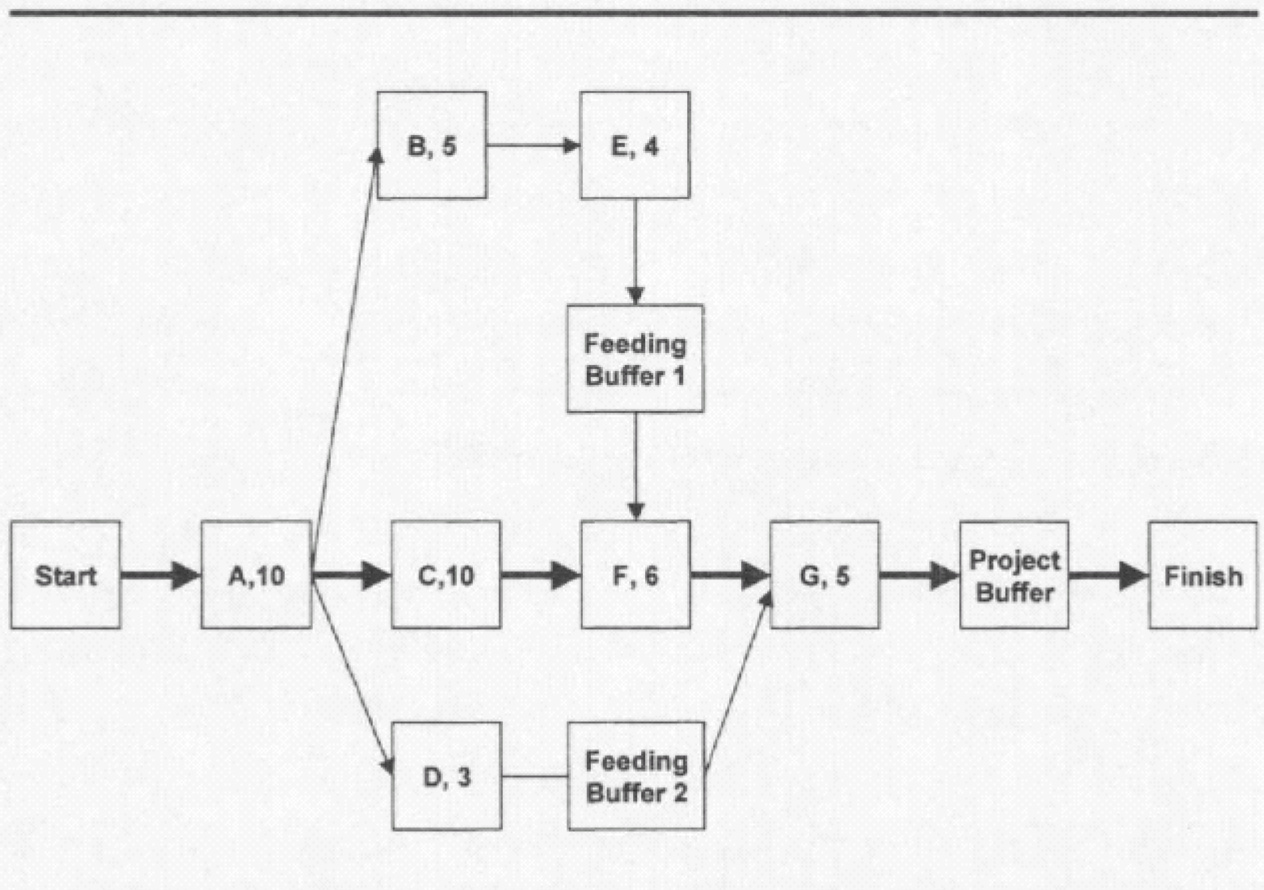

FIGURE 5: Network for project with feeding buffers

project buffer requires only 35 weeks. This four-week reduction in project time can be a very important competitive advantage in terms of both earlier project completion and cost.

In this section we have shown that there is a relationship between the size of the project buffer and the probability of completing the project by a specified time. Although the procedure was demonstrated for a simple example project, the same methods can be used for any project without restriction on the number of activities, the precedence relationships, resource constraints, or the form of the probability distributions for activity times. In the next section we turn our attention to feeding buffers.

Sizing Feeding Buffers

Goldratt [3] uses ideas from his theory of constraints to develop the concept of feeding buffers. The constraint for a project is the critical path. Feeding buffers are time buffers placed in the project network to protect the critical path. Figure 5 is the example network with feeding buffers placed where noncritical paths merge with the critical path. Again, Goldratt [3] provides little guidance on sizing these buffers.

Any activity that is not on a critical path has some slack. This slack provides a buffer for any string of activities that merge with the critical path. Project scheduling literature describes a type of slack called *free slack*, which is the time an activity can be delayed without delaying the early start time of a successor activity. Free slack is associated with the last activity in a string of activities prior to a merge event. In our example problem, activity E has a free slack of 1 and activity D has a free slack of 13.

The free slack in a network provides a natural feeding buffer for the critical path. Thus the free slack of 1 week for activity E in figure 5 provides a feeding buffer of 1 week. Similarly, the free slack of 13 for activity D provides a feeding buffer of 13 weeks. Note, however, that if a project scheduler created a feeding buffer greater than the free slack, the merging string of activities would form a *new* critical path. Accordingly, feeding buffers are provided naturally by the free slack in a project network, and project schedulers do not need to create new feeding buffers.

Problems can arise when a near-critical path becomes critical because of uncertainty in activity times. In that situation no additional protection (a feeding buffer) is available for protecting the original critical path. However, this protection is not necessary because the near-critical path has become the critical path and the project buffer applies for *all* critical paths. When the example project was simulated, activities B and E were on the critical path in 37% of the simulated trials. The project buffer includes safety time for this situation as well as for the 63% of the simulated trials when ACFG formed the critical path.